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ABSTRACT

This paper, presented at the 1979 meeting of the American Educational Research Association (AERA), investigates the affective characteristics of 120 junior high school students who participated in one or both of the first two programs of Minnesota Talented Youth Mathematics Project (MTYMP). The first year program of 1976-77 was in algebra I and II, and the second year program of 1977-78 was in geometry-trigonometry. Students were selected by their aptitude test scores in an annual talent search. No sex differences in achievement among these extremely talented youth have been found. However, the attrition by girls, especially after the first year, has been disproportionately high. Also, the attitudinal changes do exhibit sex differences. These results suggest that affective variables do affect the motivation and future plans of talented students. (HM)

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Mathematics Anxiety and the Minnesota Talented Youth Mathematics Project

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Abstract

The Minnesota Talented Youth Mathematics Project (MTYMP) provided the first replication of the fast-paced mathematics classes in Stanley's Study of Mathematically Precocious Youth (SMPY). In its two years, MTYMP has enrolled 120 junior high school pupils in one or both of its two courses: a first year program in Algebra I and II and a second year geometry-trigonometry course. MTYMP pupils are selected by their aptitude test scores in an annual talent search. Pupils thus selected have demonstrated significant achievement as measured on standardized tests of mathematics.

One goal of the MTYMP has been to attract talented girls and to enhance their attitudes and motivation in mathematics. Talent search participants have been nearly half female, and in the second year the proportion of females qualifying for the course equalled the proportion in the talent search, although that ratio was not attained the first year. In both years, there have been no sex differences in achievement among these extremely talented youth.

However, the attrition by girls especially after the first year has been disproportionately high. Also, the attitudinal changes as measured by the Mathematics Attitude Inventory (Sandman, 1973) do exhibit sex differences. In particular, the changes in attitude of boys and girls have been in opposite directions: girls increased in anxiety and decreased on scales measuring the value of mathematics, self-concept in mathematics, enjoyment of mathematics and motivation in mathematics. Boys experienced opposite trends.

For one class of students completing two years in the accelerated program, non-significant attitudinal changes over the first year were followed by significant increases in anxiety and decreases on several other dimensions during the second year. Furthermore, in most cases each individual in the class registered change in the same direction.

These results suggest that affective variables do affect the motivation and future plans of talented students. Although achievement gains were high in an accelerated program, attitudinal variables appeared to be related to pupils' enjoyment of the subject and their desire to pursue mathematics. While further investigations will be needed, these preliminary results support a concern for the affective characteristics and experiences of gifted pupils.

Mathematics Anxiety and the

Minnesota Talented Youth Mathematics Project

Educators at all levels and in all disciplines lately have focused growing attention on the needs of gifted and talented students. One subject which generally appears as a concern in such programs is mathematics.

The most extensive recent program for gifted mathematics students is the Study of Mathematically Precocious Youth (SMPY) initiated by Julien Stanley at Johns Hopkins University. A subsequent program, the Minnesota Talented Youth Mathematics Project (MTYMP), provided the first replication of the fast-paced mathematics classes of the SMPY. Now in its third year (1978-79), the MTYMP has offered three classes per year for highly gifted junior high school pupils. Results of the first two annual evaluations indicated that pupils demonstrated significant achievement as measured by standardized tests of algebra, geometry and trigonometry, and that they further experienced changes on several attitudinal variables which may relate to achievement. These affective characteristics are the concern of the present report.

Overview of the MTYMP

The MTYMP is a program of the Minnesota State Department of Education. Three classes per year enrolling approximately 25 pupils per class are offered for junior high school pupils. Two classes meet in the Twin Cities of Minneapolis - St. Paul; the third meets in Duluth. All classes are scheduled after the regular school day for thirty weekly two hour sessions. Pupils complete two years of high school algebra during the 30 weeks, and they may elect to return for a second year during which they study geometry and trigonometry. The classes are taught by three secondary school mathematics teachers from the Minneapolis and Duluth Public Schools.

Participant selection

The MTYMP participants are selected through an annual talent search. All public and private junior high schools in the two metropolitan areas are invited to nominate for the talent search pupils who have scored at the 97th percentile or above on an in-grade standardized test of mathematical aptitude or achievement. These pupils then take the School and College Ability Test (SCAT), Series II, Form 2A (Educational Testing Service, 1973), a test intended for grades nine through twelve and consisting of quantitative (SCAT-Q) and verbal (SCAT-V) subtests. The 1976 talent search, which was open to seventh, eighth and ninth graders who had not completed Algebra I, attracted 527 pupils in the Twin Cities and approximately 150 in Duluth. The talent

search participants were ranked on the basis of their SCAT-Q scores and, within each SCAT-Q score, by SCAT-V. The top scorers formed three classes as follows:

MTYMP(I)-TC 7/8	N-25	(seventh and eighth graders)
MTYMP(I)-TC 9	N-23	(ninth graders)
MTYMP(I)-D	N-17	(seventh, eighth, ninth graders)

The first two classes met in the Twin Cities, the third in Duluth. All 65 pupils earned credit for Algebra I; 64 of the 65 also completed Algebra II.

Twenty-nine pupils elected to return for the second year program: 15 from the Twin Cities (MTYMP(II)-TC 2) and 14 from Duluth (MTYMP(II)-D 2). Based on those numbers, only one new algebra class could be formed for 1977-78. Thus the 1977 talent search was limited to seventh and eighth graders in the Twin Cities. A total of 499 pupils entered the second talent search; 28 were selected to participate in the new class (MTYMP(II)-TC 7/8). Table 1 summarizes the numbers of MTYMP pupils during the first two years.

The qualifying SCAT scores of MTYMP pupils are summarized in Table 2. It should be noted that MTYMP(I) pupils were selected on their SCAT-Q scores without regard for any minimum SCAT-V. However, based on the teachers' observations that pupils with lower verbal scores seemed to experience greater difficulty in the course, MTYMP(II) pupils were required to have a minimum verbal score of 30 (out of a possible 50). This eliminated several pupils who earned higher SCAT-Q scores but who did not achieve the minimum SCAT-V, and it accounts for a slightly lower mean SCAT-Q score in the MTYMP(II)-TC 7/8 class.

Girls in the MTYMP

Of special concern to the MTYMP directors was the goal of attracting qualified girls for the program. This has met with limited success during the first two years. In the first talent search, 47 per cent of the participants were female. However, only 25 per cent of the students who qualified for the program were girls. The second year the percentage of girls both in the talent search and in the program was 46 pef cent. This was followed, however, by a disproportionately high attrition of girls from the program. Three pupils who dropped during the year all were girls. In addition, at the end of the academic year, only two of the ten girls completing algebra expressed an intent to return for the geometry-trigonometry program compared with 13 of the 15 boys who planned to return. Table 3 summarizes the participation by girls in the MTYMP.

Mathematics Achievement of MTYMP Pupils

The achievement of MTYMP pupils is evaluated in several ways. Teachers grade homework and give regular quizzes and tests. Written reports are sent to parents and to home school mathematics teachers every ten weeks. In addition, students are required to score at the 88th percentile on nationally standardized tests of mathematics achievement as criteria for being granted credit in the various subjects by their home schools. The tests selected for

Table 1

Numbers of MTYMP Pupils

1976-77	MTYMP(I)-TC 7/8		MTYMP(I)-TC 9		MTYMP(I)-D	
	Boys	Girls	Boys	Girls	Boys	Girls
Number selected						
Grade 7	7	2			3	0
Grade 8	12	4			10	2
Grade 9			17	6	1	1
Number completing						
Grade 7	6	2			3	0
Grade 8	12	4			10	2
Grade 9			17	6	1	1

1977-78	MTYMP(II)-TC 7/8		MTYMP(II)-TC 2		MTYMP(II)-D 2	
	Boys	Girls	Boys	Girls	Boys	Girls
Number selected						
Grade 7	6	2				
Grade 8	9	11	2	1	3	0
Grade 9			5	0	6	2
Grade 10			6	1	2*	1
Number completing						
Grade 7	6	2				
Grade 8	9	8	2	1	3	0
Grade 9			5	0	5	2
Grade 10			6	1	2	1

* Includes one pupil who qualified for MTYMP(II) only.

Table 2

Entry Characteristics of MTYMP Pupils

	MTYMP(I)-TC 7/8 (N=25)	MTYMP(I)-TC 9 (N=23)	MTYMP(I)-D (N=17)	MTYMP(II)-TC 7/8 (N=28)
SCAT-Q				
Raw score range	49 - 45	49 - 45	47 - 43	49 - 43
Mean*	46.52	47.04	45.00	44.82
S.D.	1.19	1.26	1.12	1.61
SCAT-V				
Raw score range	44 - 26	45 - 30	41 - 22	43 - 31
Mean**	35.64	37.57	34.18	35.93
S.D.	5.63	3.78	5.43	3.11

* Maximum score: 50. A SCAT-Q score of 45 corresponds to the 98 percentile of college bound students in the spring of ninth grade or fall of tenth grade (9S-10F). SCAT-Q scores of 47 or above are at the 99+ percentile of 9S-10F college bound students.

**Maximum score: 50. A SCAT-V score of 35 is at the 77th percentile of 9S-10F college bound students. SCAT-V scores of 40 correspond to the 95th percentile for this same norm group.

Table 3

Participation by Girls in the MTYMP

Percentage of girls	Grade 7	Grade 8	Grade 9	Total
In 1976 talent search	43 %	50 %	48 %	47 %
In 1976-77 classes	22 %	25 %	26 %	25 %
In 1977 talent search	43 %	49 %		46 %
In 1977-78 class (algebra)	25 %	55 %		46 %

this purpose were the Cooperative Mathematics Tests (Educational Testing Service, 1964) of Algebra I (COOP-A1), Algebra II (COOP-A2), geometry (COOP-G), and trigonometry (COOP-T).

Complete data on the pupils' performances on these measures are reported in the annual MTYMP evaluations (House, 1977, 1978) and are summarized in Table 4. All MTYMP pupils attained the required 88th percentile on the achievement tests, and in most cases their scores surpassed the 95th percentile.

All pupils in the three MTYMP(I) classes were given pre and post tests of Algebra II using parallel forms of the COOP-A2. The MTYMP(II)-TC 7/8 class also was pre-tested with the COOP-A1 as well as with the COOP-A2, and both second year classes had geometry pretests using the COOP-G. The Duluth class also responded to pre and post tests of the COOP-T and the COOP test of analytical geometry (COOP-AG).. In each of these nine situations, comparisons of the pre and post test scores using the t-test for related samples and a one tail test of significance showed highly significant gains ($p < .0005$). These outcomes are reported in House (1977, 1978).

For each class multiple regression analyses were performed to determine how well the selection criteria predicted success in the MTYMP. Each regression used as predictors the SCAT-Q and SCAT-V scores and sex of the student. The criterion to be predicted was either the Algebra I or the Algebra II score as measured by the COOP-A1 and COOP-A2 respectively. In all three Twin Cities algebra classes the SCAT-Q score alone was found to be a significant predictor of the COOP-A2 score ($p < .01$ for the two seventh-eighth grade classes; $p < .05$ for the ninth grade class.) For the ninth graders, the SCAT-Q also predicted success on the COOP-A1 ($p < .05$). Neither of the multiple regressions yielded significant predictions of algebra achievement in the Duluth class. The significant multiple regressions are summarized in Table 5, and the complete results are reported in House (1977, 1978).

The MTYMP pupils have consistently demonstrated significant achievement in algebra, geometry and trigonometry as measured by standardized tests in each subject, and the MTYMP has thus far achieved its goal of accelerating the mathematics learning of very gifted junior high school students. Further, in all MTYMP classes to date there have been no significant differences in the achievement of girls as compared to boys. However, there may be certain attitudinal variables which affect the performance of girls and boys in the accelerated mathematics program. These are examined further in the remainder of this paper.

Affective Characteristics of MTYMP Pupils

From the initiation of the MTYMP, the program directors have been concerned about the affective characteristics of the participants. Although the research on the effect of attitude on achievement in mathematics has shown mixed results (Aiken, 1970, 1976), the rationale for the attention to affective variables within the MTYMP has been based on two principal assumptions: First, the pupils' attitudes toward mathematics likely affect their decisions to pursue (or to avoid) mathematics in the future. Second, the pupils' self-concepts of their own ability in mathematics will likely affect their personal

Table 4

Summary of Achievement by MTYMP Pupils

	MTYMP(I) TC 7/8	MTYMP(I) TC 9	MTYMP(I) D	MTYMP(II) TC 7/8
COOP-A1 (Max=40)				
Mean	38.13	36.74	36.12	37.08
S.D.	2.21	1.84	2.83	2.14
Percentile[1]	99.6	99.6	99.2	99.6
COOP-A2 (Max=40)				
Mean	35.30	33.74	33.63	34.72
S.D.	3.81	3.67	3.16	3.30
Percentile[2]	98	97	97	98

	MTYMP(II)-TC 2	MTYMP(II) D 2	
COOP-G (Max=80)			
Mean	65.27	63.57	
S.D.	7.24	7.45	
Percentile[2]	98	98	
COOP-T (Max=40)			
Mean	29.13	28.15	
S.D.	6.80	4.86	
Percentile[2]	97	96	
COOP-AG (Max=35)			
Mean		27.08	
S.D.		3.99	
Percentile[2]		92	

[1]Percentile of class mean, ninth grade norms.

[2]Percentile of class mean, national norms.

Table 5

Summary of Significant Predictions of Achievement

	MTYMP(I) TC 7/8	MTYMP(I) TC 9		MTYMP(II) TC 7/8
Criterion	COOP-A2	COOP-A1	COOP-A2	COOP-A2
Predictor	SCAT-Q	SCAT-Q	SCAT-Q	SCAT-Q
N	24	23	23	25
R	.59	.52	.44	.54
R^2	.35	.27	.20	.29
F	11.83	7.75	5.10	9.46
df	(1,22)	(1,21)	(1,21)	(1,23)
Signif.	$p < .01$	$p < .05$	$p < .05$	$p < .01$

expectations and performances. Hence, attitude can affect achievement indirectly through personal choices and goals. In particular, these variables may have differential effects in boys and girls. Thus, another goal of the MTYMP was to maintain and enhance positive attitudes toward mathematics and toward self.

In order to monitor these traits in the pupils, pupils were asked to respond to the Mathematics Attitude Inventory (MAI) (Sandman, 1973). This instrument was administered at the time of entry into the program and again in the spring of the first and second years.

The MAI contains 48 statements with which the respondent expresses a degree of agreement or disagreement, and it yields scores on six dimensions of attitude:

Perception of the mathematics teacher: A measure of the student's view of the mathematics teacher with respect to a variety of personal characteristics.

Anxiety toward mathematics: A measure of the level of anxiety which the student feels in the presence of mathematics.

Value of mathematics in society: A measure of the student's view of the usefulness of mathematical knowledge.

Self-concept: Specifically, self-concept of ability in mathematics, a measure of the student's view of his or her own competence in the subject.

Enjoyment of mathematics: A measure of the pleasure the student derives from engaging in mathematical activity but not necessarily as compared to any other activity.

Motivation in mathematics: A measure of the student's desire to increase his or her mathematical knowledge -- specifically, the desire to do work in mathematics beyond the regular class requirements.

Sandman (1973, p. 64) reported the results of a factor analysis of the items in the MAI. The results indicated that the six attitude scales appear to measure six empirically distinct constructs, and they gave evidence of the internal validity of the instrument. The reliabilities of the six scales using Cronbach's alpha coefficient were reported to be .83, .86, .77, .83, .85 and .76, respectively (Sandman, P. 54).

Each statement of the MAI calls for the student to strongly agree, agree, disagree or strongly disagree. These responses are weighted from one to four in such a way that a positive attitude receives a high score. Scores on each of the six scales are the mean scores for the items in that scale. Hence, the range of possible scores is from one to four for each scale. A high score indicates a favorable or positive attitude on each scale except anxiety. For that scale, a high score suggests a high level of anxiety which is viewed as a negative or unfavorable characteristic.

Class means were calculated for each of the six scales on the fall and spring administrations of the MAI. These class means are shown in Table 6. Differences can be calculated as spring score minus fall score, or as Spring 2 score minus Spring 1 score. Hence a positive value of a difference would correspond to an increase on that dimension of attitude and would be seen as a desirable outcome in every case except anxiety. These class means can be viewed as descriptive characteristics of the classes as a whole. They suggest pupils with generally strong positive attitudes toward mathematics.

More information is gained by examining the changes in attitudes of various groups of pupils. It is also possible to test the significance of the changes using the t-test for related samples. Such comparisons are included in Tables 6 and 7. For the algebra pupils the changes on all six scales were generally small and nonsignificant for the class as a whole. In the case of the two MTYMP(I)-TC classes there was no attempt to examine sex differences on the attitude scales because the numbers of girls in the classes were small. However, in the MTYMP(II)-TC 7/8 the proportion of girls was large enough to prompt such an examination. The results are recorded in Table 7. With one exception, the changes recorded for boys and girls in the class also were nonsignificant. But the directions of the changes were consistently opposite for the two groups: girls showed slight increases in anxiety and slight decreases on the value, self-concept, enjoyment and motivation scales, while boys showed slight decreases in anxiety and slight increases on the other four dimensions. For the girls, the decrease in their perception of the value of mathematics was significant ($p < .05$). Two other changes, the decreases in enjoyment and motivation in girls, approached but did not quite reach significance at the .05 level. (Both surpassed the $p < .01$ level).

A similar comparison was drawn between the attitude changes of the thirteen pupils who intended to return to the 1978-79 program and the ten who did not. Once again only one change reached significance (a decrease in motivation among non-returnees, $p < .05$), but the directions of the attitudinal changes recorded by the two groups were opposite on all but the perception of the teacher scale. These outcomes suggest that affective characteristics of the MTYMP pupils do influence their attitudes toward mathematics and their future involvement with the subject.

The attitude changes for the second year classes were more diverse and therefore more puzzling. For the Duluth pupils no data were available from the time they entered the program, but scores on the MAI administered at the end of each year showed no significant changes over the second year. Among MTYMP(II)-TC 2 pupils this was not the case. They displayed significant increases in anxiety and significant decreases on the value, self-concept and enjoyment scales during the second year. By contrast, over the first year the attitudes of these pupils did not change significantly on five of the six scales. The one change which was significant was an increase in their perception of the value of mathematics. However, the decrease on this same scale over the second year yielded a nonsignificant change for the two year period. The increase in anxiety and the decreases in self-concept and enjoyment were significant over two years.

Table 6

Mathematics Attitude Inventory Class Means

MAI Scales	Means	Algebra Classes (I)-TC 7/8	(I)-TC 9	(II)-TC 7/8	Geometry/Trigonometry Classes (II)-TC 2	(II)-D 2
Teacher:	Entry	3.45	2.99	3.32	3.14	
	Spring 1	3.43	3.07	3.44	3.40	3.24
	Spring 2				3.16	3.60
Signif. of Change*		0	0	0	0,0,0	0
Anxiety:	Entry	1.44	1.54	1.45	1.44	
	Spring 1	1.42	1.62	1.46	1.45	1.48
	Spring 2				1.72	1.71
Signif. of Change*		0	0	0	0,p<.01,p<.05	0
Value:	Entry	3.48	3.43	3.57	3.48	
	Spring 1	3.72	3.42	3.52	3.72	3.59
	Spring 2				3.32	3.68
Signif. of Change*		p <.05	0	0	p<.05,p<.001, 0	0
Self-concept:	Entry	3.40	3.50	3.32	3.42	
	Spring 1	3.24	3.32	3.30	3.46	3.21
	Spring 2				3.11	3.23
Signif. of Change*		0	0	0	0,p<.01,p<.001	0
Enjoyment:	Entry	3.42	3.30	3.30	3.51	
	Spring 1	3.35	3.19	3.21	3.52	3.33
	Spring 2				3.19	3.33
Signif. of Change*		0	p <.01	0	0,p<.001,p<.01	0
Motivation:	Entry	3.00	2.57	2.72	2.88	
	Spring 1	2.67	2.36	2.65	2.84	2.94
	Spring 2				2.70	3.00
Signif. of Change*		p <.01	p < .05	0	0,0,0	0

*t-test for related samples; two-tailed test. For MTYMP(II)-TC 2 class three significance values relate to (first year change, second year change, two year change).

Table 7

Attitude Changes of MTYMP(II)-TC 7/8 Pupils

MAI Scale	All S's N=23	Girls N=10	Boys N=13	Will Return N=13	Not Return N=10
Teacher					
Change	0.12	0.01	0.20	0.10	0.14
t					
Signif.	none	none	none	none	none
Anxiety					
Change	0.01	0.08	-0.12	-0.03	0.06
t					
Signif.	none	none	none	none	none
Value					
Change	-0.05	-0.14	0.02	-0.01	-0.10
t		-2.33			
Signif.	none	$p < .05$	none	none	none
Self-concept					
Change	-0.02	-0.19	0.11	0.04	-0.10
t					
Signif.	none	none	none	none	none
Enjoyment					
Change	-0.09	-0.40	0.14	0.07	-0.31
t					
Signif.	none	none	none	none	none
Motivation					
Change	-0.07	-0.32	0.14	0.16	-0.35
t					-2.69
Signif.	none	none	none	none	$p < .05$

All tests are two tailed tests. Only significant t values are recorded.

It should be noted that in the MTYMP(II)-TC 2 class the changes in attitude scores over the second year showed that all but one of the pupils increased on the anxiety scales and all but one individual decreased on the value, self-concept and enjoyment scales. Thus there were some consistent patterns in the directions of these changes as well as significant overall changes. Yet no firm conclusions can be drawn since the patterns of attitude change differed for the two geometry-trigonometry classes. It also should be emphasized that in all MTYMP classes even when changes did occur the mean scores of the pupils did not differ greatly among the classes, and these scores all fell in a high score range.

Relationships Between Attitude and Achievement

Two additional questions sought to determine the existence of any relationships between the MTYMP experience and the attitudes of the pupils: Is success in the MTYMP related to attitude? In success in the MTYMP related to changes in attitude?

To determine whether success in the MTYMP predicted attitude at the end of the year, multiple regressions were performed on each class using as predictors the sex, grade, SCAT-Q, SCAT-V and achievement scores of the pupils. For the algebra classes, CCOP-A2 was taken as the achievement measure; in the second year classes COOP-A2, COOP-G and COOP-T achievement scores were entered. Each regression was repeated six times in each class using as the respective dependent variables the six MAI scores from the spring administration of that instrument. Those regressions which yielded significant predictions ($p < .05$) are summarized in Table 8. Although there are no strong trends in these results, the following patterns warrant further examination in future classes:

First, in the two classes of seventh and eighth graders and in the first Duluth class (seventh, eighth and ninth graders), success in Algebra II predicted scores on one or more of the self-concept, enjoyment and motivation scales. Similarly, in the second year Duluth class, achievement in trigonometry or geometry continued to be related to self-concept and enjoyment scales as well as to the value construct. Since measures at the end of the year showed significant correlations among the MAI scales of self-concept, enjoyment and motivation ($p < .05$), these relationships to achievement may suggest a complex interaction among success in the course and attitudes toward mathematics and self.

Second, in the MTYMP(II)-TC 7/8 class where pupils were required to have a minimum SCAT-V score of 30, the SCAT-V score showed a positive relationship to anxiety and a negative relationship to value and enjoyment. In this class there was a nonsignificant negative correlation between SCAT-Q and SCAT-V. Hence it may be that pupils with relatively higher verbal and relatively lower quantitative scores would experience more anxiety and less enjoyment from mathematics, but more information will be needed before any conclusions can be drawn.

The question of whether success in the MTYMP would predict changes in attitude was addressed by repeating the multiple regressions described above but using as the dependent variables the changes in MAI scores on each of the six scales. The outcomes for changes during the first course are given in Table 9. Predictions of changes during the second year failed to reach sig-

Table 8

Summary of Significant Predictions of Attitude

Attitudes After One Year

Criterion:	Teacher	Anxiety	Value	Self-concept	Enjoyment	Motivation
MTYMP(I)-TC 7/8						
Predictors		Grade[1]		Grade[1]	COOP-A2 (+)	COOP-A2 (+)
R^2		.20		.21	.29	.25
F		4.91		5.27	8.33	6.68
df		(1,20)		(1,20)	(1,20)	(1,20)
Signif.		p<.05		p<.05	p<.01	p<.02
MTYMP(I)-TC 9						
Predictors						Sex[2]
R^2						.19
F						4.43
df						(1,19)
Signif.						p<.05
MTYMP(I)-D						
Predictors		SCAT-Q (-)		COOP-A2		
R^2		.39		.33		
F		6.29		4.94		
df		(1,10)		(1,10)		
Signif.		p<.05		p<.05		
MTYMP(II)-TC 7/8						
Predictors		SCAT-V (+)	SCAT-V (-)		SCAT-V (-)	Grade[3]; COOP-A2 (+)
R^2		.32	.23		.18	.25
F		10.52	6.56		4.97	3.47
df		(1,22)	(1,22)		(1,22)	(2,21)
Signif.		p<.01	p<.02		p<.05	p<.05

Attitudes After Two Years

MTYMP(II)-TC 2						
(No significant predictions for this class)						
MTYMP (II)-D 2						
Predictors			COOP-T (+)	COOP-T (+)	COOP-G (+);Grade[4]	
R^2			.44	.75	.51	
F			7.90	29.55	4.61	
df			(1,10)	(1,10)	(2,9)	
Signif.			p<.02	p<.001	p<.05	

1. Younger pupils had lower anxiety scores and higher self-concept scores. 2. Males had higher motivation scores.
3. Younger pupils had higher motivation scores. 4. Older pupils had higher enjoyment scores.

Table 9

Summary of Significant Predictions of Attitude Change

Criterion:	Teacher	Anxiety	Value	Self-concept	Enjoyment	Motivation
MTYMP(I)-TC 7/8						
Predictors		SCAT-V (+)		COOP-A2(+)	COOP-A2 (+)	COOP-A2 (+)
R^2		.19		.35	.27	.61
F		4.79		10.72	7.40	31.26
df		(1,20)		(1,20)	(1,20)	(1,20)
Signif.		p<.05		p<.01	p<.02	p<.001
MTYMP(I)-TC 9						
Predictors		SCAT-V (+)				
R^2		.19				
F		4.46				
df		(1,19)				
Signif.		p<.05				
MTYMP(II)-TC 7/8						
Predictors		SCAT-V (+)	SCAT-V (-)		COOP-A2	Sex[1]
R^2		.22	.38		.18	.20
F		5.95	12.68		4.46	5.19
df		(1,21)	(1,21)		(1,21)	(1,21)
Signif.		p<.05	p<.01		p<.05	p<.05

[1]Males showed greater increases in motivation.

nificance for the two geometry-trigonometry classes. Once again, two observations warrant further study:

First, for the two seventh and eighth grade classes, success in Algebra II seemed to relate to increases in one or more of the self-concept, enjoyment and motivation scores. And, second, in all three algebra classes pupils with higher verbal scores appeared to experience greater increases in anxiety. Until additional information is available, however, these trends are noted without further comment since it will be remembered that the changes in MAI scores among algebra pupils tended to be nonsignificant (see Table 6).

One final inquiry into the attitudinal effects among MTYMP pupils focused on the individual's decision whether or not to return for the second year. A multiple regression analysis was performed on each of the three Twin Cities algebra classes using as predictors the pupils' sex, grade, SCAT-Q, SCAT-V, COOP-A2 and spring MAI scores, and using the return decision as the dependent variable. For the MTYMP(I)-TC 7/8 group, no significant prediction equation was obtained. For the MTYMP(II)-TC 7/8, sex alone was a significant predictor (R^2=.55, $p < .001$). (It will be remembered that this was the class in which only two of ten girls planned to return.) In the ninth grade algebra class, the pupils' MAI value score was a significant positive predictor (R^2=.24, $p < .05$) of the choice to return. These outcomes are considered further in the discussion below.

Discussion

There is little doubt that the MTYMP has thus far been successful in accelerating the mathematics achievement of the pupils as measured by their scores on standardized tests of algebra, geometry and trigonometry. These results have been consistent across all six classes during the first two years of the program.

The affective outcomes of the MTYMP are more complex and difficult to interpret. It is important to emphasize that the findings reported here must be viewed as exploratory only. The MTYMP pupils represent a unique population of highly gifted mathematics pupils enrolled in a special accelerated program. Their scores on the various attitude scales cannot be compared to those of junior high school pupils in the general population. Neither can the MTYMP classes be compared to each other since they differed on the selection criteria of grade level, SCAT-Q and SCAT-V. Further, while the pupils may share similar experiences in the weekly MTYMP classes, their mathematics experiences in their home schools vary considerably, and there are no data available to investigate the interactions among pupil characteristics, MTYMP outcomes and home school mathematics experiences. Nevertheless, there are several preliminary outcomes which warrant further investigation and which contribute to an understanding of the needs and characteristics of extremely gifted mathematics pupils.

First, as seen in Table 6, there was a trend toward a nonsignificant but negative change in self-concept among the algebra students. Since the MAI was first administered immediately after their selection to the MTYMP, it may be that their entry scores were inflated by the fact of their selection from among the very large pool of talent search participants. Another plausible

explanation for the self-concept change comes from the composition of the MTYMP classes. Because self-concept generally derives from an individual's perception of his or her own ability with respect to the peer group, these talented pupils would be expected to score high on the self-concept scale. In the MTYMP, however, pupils may experience for the first time a peer group of equally talented mathematics students, and it would not be surprising if they began to redefine their self-concepts relative to these other gifted pupils. In any event, though, it must be noted that the self-concept scores of the pupils on all administrations of the MAI are very high on the four point scale for that instrument.

A second trend observed in Table 6 is toward lower scores on the motivation scale. Here one must recall that the MAI measure of motivation has a fairly specialized definition -- ie, motivation to pursue mathematics beyond the requirements of the class. In the MTYMP program, pupils meet weekly and they are assigned large numbers of textbook pages and homework problems for independent work between classes. In addition, the MTYMP course itself is outside of the pupils' regular school requirements. Thus it is not difficult to understand a change in their eagerness to do more mathematics outside of the requirements of an already demanding class. This motivation factor, however, may be a key variable in a student's success in a program demanding much independent learning. Unfortunately, the motivation scale of the MAI is the most difficult to interpret because it has the fewest items loading on that factor (Sandman, 1973). A measure of motivation which is more inclusive than the present scale might aid in understanding that variable.

The increases in anxiety observed in one geometry class and in the ninth grade algebra class may be related to the age of the pupils. Perhaps older pupils view success in mathematics as more relevant to their long range goals and hence they may be more concerned about their performance in the subject. However, more information is needed before any such conclusions can be drawn. Similarly, the positive relationship between verbal scores and increased anxiety in all three algebra classes needs more study. And, as was noted in the case of self-concept above, it should be remembered that the anxiety scores of the MTYMP pupils show results (in this case low scores) which certainly would be viewed as acceptable on the four-point scale.

In general, the algebra students exhibited relatively few significant changes on the MAI scales while the geometry students in the Twin Cities class showed significant changes on four of the six scales. Unfortunately, no data were available on the first year changes in the MAI scores of the Duluth pupils, and the differences in the affective outcomes of the two second year classes cannot be explained. It may be that these changes in attitude are related to the age or grade level of the pupils. They also may be related to differences in the subject matter (algebra vs. geometry/trigonometry).

The question of age or grade level may, in fact, be related to differences between junior and senior High school. Pupils attending senior high schools likely have available to them a wider range of alternatives both related and unrelated to mathematics. Thus, for example, their enjoyment of mathematics might be tempered by the wider range of other activities in which they could engage. If this is the case, it might also help to account for the significance of the ninth grade students' scores on the value scale as a predictor of the decision to return to the MTYMP. Since Minnesota requires mathematics of pupils

through ninth grade, pupils entering senior high school will be able to choose between mathematics and no mathematics while junior high pupils will essentially choose only among available mathematics courses. Hence it may be that senior high school pupils electing the more demanding MTYMP program are those who view mathematics as having greater value. However, as with other preliminary results noted here, this, too, demands further investigation.

An additional consideration which might be addressed in future second year classes concerns the possible relationship of attitudinal variables to the geometry curriculum. In the two geometry classes offered to date, the Twin Cities class studied the subject using a transformational geometry curriculum while the Duluth class followed a traditional approach. No attempt has been made to determine whether the difference in the curricular orientation is related to the observed differences on the MAI scores in the two groups. It is significant to note, however, that there were no achievement differences between the classes even though both were assessed on a criterion test which assumed a traditional geometry approach.

Finally, the high rate of attrition among the girls in the program continues to be a serious concern. While the affective changes of pupils in the most recent algebra class were not statistically significant, the opposite directions observed between the boys' and girls' scores on the MAI scales cannot be ignored. The fact that most of the girls chose not to continue beyond the first year suggests that attitudinal variables do affect the motivation and future plans of talented mathematics students. Although achievement gains were high in the accelerated program, the MAI scales appear to measure characteristics which relate to pupils' enjoyment of the subject and their desire to pursue mathematics. While further investigations are needed, these preliminary results support a concern for the affective characteristics and experiences of gifted pupils.

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